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(54) **Dynamic filter separator**

Dynamischer Filterabscheider

Séparateur à filtre dynamique

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(56) References cited:
EP-A- 0 238 335 **WO-A-92/21426**

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Description

The invention relates to an apparatus and a method for separating a feed fluid, particularly a suspension into a less concentrated or even pure phase (filtrate fluid) and a more concentrated phase (concentrate fluid).

In areas such as biotechnology, waste water treatment, pharmacy, medicine and the beverage industry, it is a frequent problem to separate solid particles from a feed fluid, such as enzymes or yeast in an aqueous solution, blood in plasma or pulp from juice, etc.

The EP-A-0 238 335 discloses an apparatus for fractionating a cell suspension having a disc like rotating body.

Previously known dynamic filter separators work with a two chamber system. The feed fluid is impelled in a first chamber, called concentrate chamber which is separated from a second chamber, the filtrate chamber, by a partially permeable wall (semi-permeable membrane). In the second chamber the filtrate is collected from the whole plane of the membrane.

Said concentrate chamber is connected to a feed fluid entering means and a concentrate fluid exiting means, the filtrate chamber is connected to a filtrate fluid exiting means.

Such a filter is called dynamic, when a relative motion of the suspension in the concentrate chamber along the membrane is induced by any means, for example a rotatable disc. Thus, clogging of the membrane pores is avoided or at least diminished.

In this state of the art the effect of different degrees of separation of the suspension at different locations at the membrane had not been taken into account. Any inhomogeneous behavior of the separation process due to e.g. parameters of the feed fluid such as pressure, temperature, concentration or velocity in the concentrate chamber has not been considered.

One of the objects of the invention is to provide a dynamic filter separator and a dynamic filtration method with improved separation characteristics.

A further object of this invention is to provide a dynamic filter separator permitting obtaining more information about a dynamic separation process.

A yet further object of this invention is to provide a dynamic filter separator as a tool for the development of a dynamic filter separator and process specifically adapted to a particular separation problem.

The invention provides a separator and method in which partial filtrate fluids are collected as a plurality of filtrate fluid streams in a plurality of separate parallel filtrate chambers. The filtrate chamber is divided into several partial filtrate chambers, each of them connected to a different portion of the partially permeable wall or membrane and receiving that portion of the filtrate which passes therethrough.

Other features, modifications and applications of the separator and method of this invention are described in the claims.

This multi-chamber system provides a different kind of separation for a partial filtrate fluid in comparison to the mixed filtrate fluid that is received by a two-chamber system. Partial filtrate fluids then can e.g. differ in the degree of separation. Thus, the feed fluid is separated differentially into a multitude of filtrate fluids with generally different concentration, flow rates or other properties being different from one partial filtrate stream to the next.

There are several advantages to this differential separation. A higher degree of separation for a partial stream can be obtained. The separation process itself can be investigated by analyzing the degree of separation depending on the location at the membrane where the filtrate fluid is connected as well as depending on other parameters, e.g. geometrical parameters (gap shape, surface structure of rotatable element). It is preferred to install one or more sensors at the filtrate and/or concentrate chambers in order to monitor physical or chemical properties of the fluids, such as concentration, temperature, pressure or flow rate depending on the location in said chambers. In this case a differential separation process does not have to be run by trial and error but can be controlled and predetermined systematically.

It is also possible to provide membranes with different properties for different partial filtrate chambers, such that the membrane is composed of a plurality of portions of different membranes. Therefore, the possibility of testing different membranes at the same time arises in order to find a membrane that meets best the special demands of the specific case.

Especially for testing and development purposes it is advantageous to build the housing of the filter separator of at least two parts, such that relevant parts (membrane, relative motion inducing means) for the separation process can easily be changed.

Figures 1 and 2 show a preferred embodiment of a differential dynamic filter separator, Fig. 2 being a cross-sectional view along line II-II of the separator of Fig. 1.

An apparatus according to Figures 1 and 2 shows a ring channel differential rotational shearing gap filter separator.

A feed fluid is fed into the concentrate chamber 4, which is formed by lid 4a and bottom 4b, via the central feed fluid entering means 1, a hollow shaft. In the concentrate chamber 4 there is installed a rotatable disc 11. It forms a gap 12 with the semi-permeable membrane 6. Rotating the disc 11 induces a relative motion of the feed fluid in the gap 12 along the membrane 6, one of the possible effects being in to avoid or diminish clogging of the membrane pores. The filtrate chamber 5 of the system is divided into several partial filtrate chambers 5_1 to 5_n which are arranged in this preferred embodiment as concentric rings in the bottom 4b around the rotational axis 10 of the rotatable disc 11. The suspension that was fed near the middle of the rotatable disc 11 is led to the outer edge of the concentrate chamber 4. The feed fluid is concentrated each

time when passing a ring channel with a membrane and a connected partial filtrate chamber. The different filtrate fluids which are collected in said ring channels 5 are drained by filtrate exiting means 3. Thus a differential separation process occurs. The different collected filtrate fluids can have different properties, e.g. different concentration of particles. The remaining concentrate fluid is expelled by the concentrate exiting means 2. In order to exchange the rotatable disc and the membrane easily the housing of the filter separator is horizontally divided into two parts. Preferably, these two parts are connected by bolts 8 and a sealing 7.

In a preferred embodiment of this invention sensors 13 are provided in each partial filtrate chamber $5_1, \ldots, 5_n$ or the outlet conduit 3 thereof. These sensors 13 may e.g. be flow rate sensors, concentration sensors, pH sensors, viscosity sensors, pressure sensors.

The filter separator may also in a further embodiment have radial sectors of membrane portions with different properties instead of the ring channel arrangements of Figure 1. Several membranes can thus be installed and tested under the same circumstances.

The following two examples illustrate the invention.

Example 1

In the differential filtration apparatus as described above four different baker's yeast solutions were employed to determine the separation quality of a membrane. The flux in liters per hour for the four different solutions at the seven different ring channels have been determined and the results have been plotted in Figure 3. As can be seen, the flux increases from the inner ring channel 5_1 to the outer ring channel 5_n. The dependency is particularly strong for the more diluted solution of 5 percent, while the other concentrations of 20 weight percent, 60 weight percent and 80 weight percent, respectively, show a smaller, but still significant dependency of the flux upon the radius r of the ring channel. The filter membrane used for this experiment was a 0.2 micrometer nominal nylon membrane, marketed under the trademark "Ultipor®" by Pall Corporation.

Example 2

In this example a solution of homogenized E. coli was used in the same apparatus. The membrane employed was a 0.2 micrometer nominal PVDF membrane, commercially available from Pall Corporation under the trademark "Fluorodyne®". Figure 4 shows the dependency of the protein transmission plotted on the ordinate vs. the average radius r_m of the ring channel in mm ranging from 25 to 85 mm. The corresponding local velocity v_R of the rotor is also shown in this Figure 4. This local velocity above the membrane portion covering the respective ring channel is between about 6 and about 20 m/sec. The plotted data shows that the transmission rate, which is the ratio of protein concentration in the filtrate to the protein concentration in the concentrate ranges from about 25 percent to 100 percent.

Test runs have been carried out with a PVDF membrane of 0.2 micrometer (commercially available under the trademark "Fluorodyne II®" from Pall Corporation) under 200 mbar over 1.5 hours (crosses in the diagram) and with a 0.2 micrometer nylon membrane (commercially available under the trademark "Bio-inert II®" from Pall Corporation) under a pressure of 700 mbar over 4.5 hours (dots in the diagram).

Attention is drawn to the fact that in this example the purpose was to determine how efficiently the membrane passes the homogenization products, i.e. the smaller protein molecules. For this test a transmission of 100 percent is desirable. The results clearly demonstrate that from above roughly 55 mm average radius of the channel the transmission is 100 percent.

Further, it is pointed out that the above examples are not about examining protein transmission globally, but for a special protein in particular.

Claims

1. A dynamic filter separator comprising

   a housing;

   a supporting structure having one essentially plane surface carrying a partially permeable wall (6) separating the space within the housing of the dynamic filter separator into a concentrate chamber (4) and a filtrate chamber (5);

   a feed fluid entering means (1) and a concentrate fluid exiting means (2) connected to said concentrate chamber (4);

   a means (11) inducing a relative motion between the feed fluid in said concentrate chamber (4) and said partially permeable wall (6) with at least a component parallel to the partially permeable wall (6),

   a filtrate fluid exiting means (3) connected to said filtrate chamber (5),

   characterized in that

   said filtrate chamber (5), which is connected via said partially permeable wall (6) on said one essentially plane surface with said concentrate chamber (4), is divided into a plurality of partial filtrate chambers (5_1, 5_2, ..., 5_n) each collecting filtrate fluid from a different portion of said partially permeable wall (6) through a respective access in said supporting structure, said accesses being located in said one plane.

2. The dynamic filter separator according to claim 1, wherein

said means (11) inducing a relative motion is a rotatable part adjacent to said partially permeable wall (6) such that a gap (12) is formed between said rotatable part (11) and said partially permeable wall (6).

3. The dynamic filter separator according to claim 2, wherein

said rotatable part (11) is a rotatable, preferably circular disc.

4. The dynamic filter separator according to claims 2 or 3, wherein

said feed fluid entering means (1) is connected to said concentrate chamber (4) near the rotational axis (10) of said rotatable part (11) and disc, respectively.

5. The dynamic filter separator according to any of the preceding claims, wherein

said housing of the dynamic filter separator is composed of at least two parts arranged and constructed such that the housing can be easily opened such that said partially permeable wall (6) and/or said means (11) inducing said relative motion are easily exchangeable.

6. The dynamic filter separator according to any of the preceding claims, wherein

said portions of said partially permeable wall (6) have different properties.

7. The dynamic filter separator according to any of the preceding claims, wherein

said portions of said partially permeable wall (6) are concentric annular rings.

8. The dynamic filter separator according to any of the preceding claims, wherein

said portions of said partially permeable wall (6) are radial sectors.

9. The dynamic filter separator according to any of the preceding claims, wherein

at least one sensor (13) in at least one of said partial filtrate chambers (5_1, 5_2, ..., 5_n) for determining and optionally monitoring at least one property of said filtrate fluid is provided.

10. The dynamic filter separator according to any of the preceding claims, wherein

at least one sensor (13) for determining and optionally monitoring at least one property of said concentrate fluid is provided.

11. A method for separation employing a dynamic filter separator according to any of the preceding claims said method being characterized by

a) feeding said feed fluid into said concentrate chamber (4) with a relative motion between said feed fluid and the partially permeable wall (6) imparting on said feed fluid at least a component of its movement parallel to the partially permeable wall (6);

b) collecting separate streams of filtrate fluid in partial filtrate chambers (5_1, 5_2, ..., 5_n) from different portions of said partially permeable wall (6).

12. The method in according to claim 11 further comprising measuring at least one of the properties flow rate (cm^3/second), density, composition, concentration, pressure of said filtrate fluid of said partial filtrate chambers (5_1, 5_2, ..., 5_n), etc.

13. The method according to claim 11 or 12 further comprising withdrawing concentrate fluid from said concentrate chamber (4).

14. The method according to one of the preceding method claims wherein said means inducing a relative motion comprises a rotatably arranged element (11) forming a gap (12) between said element (11) and said partially permeable wall (6), said disc (11) being rotated at a defined speed.

15. The method according to one of the preceding method claims, further comprising the steps of changing at least one parameter of said dynamic filter separator and/or of said method, and carrying out at least one measurement of a parameter of said separation method prior to and after said change.

Patentansprüche

1. Dynamische Filtertrennvorrichtung mit

einem Gehäuse;

einer Stützstruktur mit einer im wesentlichen ebenen Oberfläche, die eine teilweise durchlässige Wand (6) trägt, welche den Raum innerhalb des Gehäuses der dynamischen Fil-

tertrennvorrichtung in eine Korzentratkammer (4) und eine Filtratkammer (5) trennt;

einer Permeat-Eintrittseinrichtung (1) und einer Konzentrat-Austrittseinrichtung (2), welche mit der Konzentratkammer (4) verbunden ist;

einer Einrichtung (11), welche eine Relativbewegung zwischen dem Permeat in der Konzentratkammer (4) und der teilweise durchlässigen Wand (6) induziert mit zumindest einer Komponente parallel zu der teilweise durchlässigen Wand (6);

einer Filtrat-Austritteinrichtung (3), welche mit der Filtratkammmer (5) verbunden ist,

dadurch gekennzeichnet, daß

die Filtratkammer (5), welche über die teilweise durchlässige Wand (6) auf dieser im wesentlichen ebenen Oberfläche mit der Konzentkammer (4) verbunden ist, unterteilt st in eine Vielzahl von partiellen Filtratkammern (5_1, 5_2, ..., 5_n) von denen jede Filtrat von einem anderen Abschnitt der teilweise durchlässigen Wand (6) durch einen entsprechenden Zugang in dieser Stützvorrichtung sammelt, wobei derartige Zugänge der einen Ebene angeordnet sind.

2. Dynamische Filtertrennvorrichtung nach Anspruch 1, wobei die Einrichtung (11), welche eine Relativbewegung induziert, ein rotierbares Teil neben der teilweise durchlässigen Wand (6) ist, so daß ein Spalt (12) zwischen dem rotierbaren Teil (11) und der teilweise durchlässigen Wand (6) gebildet wird.

3. Dynamische Filtertrennvorrichtung nach Anspruch 2, wobei das rotierbare Teil (11) eine rotierbare, vorzugsweise kreisförmige Scheibe ist.

4. Dynamische Filtertrennvorrichtung nach den Ansprüchen 2 oder 3, wobei die Permeat-Eintrittseinrichtung (1) mit der Konzentratkammer (4) nahe an der Rotationsachse (10) des rotierbaren Teils (11) bzw. der Scheibe verbunden ist.

5. Dynamische Filtertrennvorrichtung nach einem der vorhergehenden ansprüche, wobei das Gehäuse der dynamischen Filtertrennvorrichtung aus zumindest zwei Teilen besteht, die so angeordnet und aufgebaut sind, daß das Gehäuse leicht geöffnet werden kann, damit die teilweise durchlässige Wand (6) und/oder die Einrichtung (11), welche die Relativbewegung induziert, leicht austauschbar sind.

6. Dynamische Filtertrennvorrichtung nach einem der vorhergehenden Ansprüche, wobei Abschnitte der teilweise durchlässigen Wand (6) unterschiedliche Eigenschaften haben.

7. Dynamische Filtertrennvorrichtung nach einen der vorhergehenden Ansprüche, wobei die Abschnitte der teilweise durchlässigen Wand (6) konzentrische Kreisringe sind.

8. Dynamische Filtertrennvorrichtung nach einen der vorhergehenden Ansprüche, wobei die Abschnitte der teilweise durchlässigen Wand (6) radiale Sektoren sind.

9. Dynamische Filtertrennvorrichtung nach einem der vorhergehenden ansprüche, wobei zumindest ein Sensor (13) in zumindest einer der partiellen Filtratkammern (5_1, 5_2, ..., 5_n) bereitgestellt ist zum Bestimmen und wahlweise Überwachen von zumindest einer Eigenschaft des Filtrats.

10. Dynamische Filtertrennvorrichtung nach einem der vorhergehenden Ansprüche, wobei zumindest ein Sensor (13) zum Bestimmen und wahlweisen Überwachen zumindest einer Eigenschaft des Konzentrats bereitgestellt ist.

11. Trennverfahren unter Verwendung einer dynamischen Filtertrennvorrichtung nach einem beliebigen der vorhergehenden Ansprüche

wobei das Verfahren **gekennzeichnet** ist durch die folgenden Schritte:

(a) Einspeisen des Permeats in die Konzentratkammer (4) mit einer Relativbewegung zwischen dem Permeat und der teilweise durchlässigen Wand (6), wobei dem Permeat zumindest eine Bewegungskomponente parallel zu der teilweise durchlässigen Wand (6) mitgegeben wird;
(b) Sammeln getrennter Ströme von Filtrat in partiellen Filtratkammern (5_1, 5_2, ..., 5_n) von unterschiedlichen Abschnitten der teilweise durchlässigen Wand.

12. Verfahren nach Anspruch 11, bei dem weiterhin zumindest eine der Eigenschaften des Filtrats der partiellen Filtratkammern (5_1, 5_2, ..., 5_n) gemessen wird, wie z.B. die Flußrate (cc/sec.) die Dichte, die Zusammensetzung, die Konzentration, der Druck etc.

13. Verfahren nach Anspruch 11 oder 12, bei welchem Konzentrat von der Konzentratkammer (4) abgezogen wird.

14. Verfahren nach einem der vorhergehenden Verfahrensansprüche, wobei die Einrichtung (11), welche eine Relativbewegung induziert, ein rotierbar angeordnetes Element (11), welches einen Spalt (12) zwischen dem Element (11) und der teilw ise durchlässigen Wand (6) bildet, wobei in dem Verfahren die Scheibe (11) mit einer definierten Geschwindigkeit rotiert wird.

15. Verfahren nach einem der vorhergehenden Verfahrensansprüche, wobei weiterhin zumindest ein Parameter der dynamischen Filtertrennvorrichtung und/oder des entsprechenden Verfahrens verändert wird, und zumindest eine Messung eines Paramters des Trennverfahrens durchgeführt wird, und zwar vor und nach der Veränderung.

Revendications

1. Séparateur formant filtre dynamique, comportant :

un boîtier,
une structure de support ayant une première surface pratiquement plane supportant une paroi partiellement perméable (6) séparant l'espace existant à l'intérieur du boîtier du séparateur formant filtre dynamique en une chère de concentré (4) et une chambre de filtrat (5),
des moyens d'entrée de fluide d'alimentation (1) et des moyens de sortie de fluide concentré (2) reliés à ladite chambre de concentré (4),
des moyens (11) induisant un mouvement relatif entre le fluide d'alimentation situé dans la chambre de concentré (4) et ladite paroi partiellement perméable (6), ayant au moins une composante parallèle à la paroi partiellement perméable (6),
des moyens de sortie de filtrat (3) reliés à ladite chambre de filtrat (5),

caractérisé en ce que

ladite chambre de filtrat (5), qui est reliée via ladite paroi partiellement perméable (6) située sur ladite première surface pratiquement plane, à ladite chambre de concentré (4), est divisée en plusieurs chambres de filtrat partiel (5_1, 5_2, ..., 5_n), chacune collectant un filtrat provenant d'une partie différente de ladite paroi partiellement perméable (6) à travers un accès respectif situé dans ladite structure de support, lesdits accès étant situés dans ledit plan.

2. Séparateur formant filtre dynamique selon la revendication 1, dans lequel

lesdits moyens (11) induisant un mouvement relatif sont une partie rotative adjacente à ladite paroi partiellement perméable (6) de telle sorte qu'un espace (12) est formé entre ladite partie rotative (11) et ladite paroi partiellement perméable (6).

3. Séparateur formant filtre dynamique selon la revendication 2, dans lequel

ladite partie rotative (11) est un disque rotatif de préférence circulaire.

4. Séparateur formant filtre dynamique selon la revendication 2 ou 3, dans lequel

lesdits moyens d'entrée de fluide d'alimentation (1) sont reliés à ladite chambre de concentré (4) à proximité de l'axe de rotation (10) de ladite partie rotative (11) et du disque, respectivement.

5. Séparateur formant filtre dynamique selon l'une quelconque des revendications précédentes, dans lequel :

ledit boîtier du séparateur formant filtre dynamique est constitué d'au moins deux parties agencées et construites de telle sorte que le boîtier peut être facilement ouvert de telle sorte que ladite paroi partiellement perméable (6) et/ou lesdits moyens (11) induisant ledit mouvement relatif peuvent être facilement échangés.

6. Séparateur formant filtre dynamique selon l'une quelconque des revendications précédentes, dans lequel

lesdites parties de ladite paroi partiellement perméable (6) ont des propriétés différentes.

7. Séparateur formant filtre dynamique selon l'une quelconque des revendications précédentes, dans lequel

lesdites parties de ladite paroi partiellement perméable (6) sont des anneaux circulaires concentriques.

8. Séparateur formant filtre dynamique selon l'une quelconque des revendications précédentes, dans lequel

lesdites parties de ladite paroi partiellement perméable (6) sont des secteurs radiaux.

9. Séparateur formant filtre dynamique selon l'une quelconque des revendications précédentes, dans lequel

au moins un premier détecteur (13) situé dans au moins une première desdites chambres de filtrat partiel (5_1, 5_2, ..., 5_n) est agencé pour déterminer et gérer en option au moins une propriété dudit filtrat.

10. Séparateur formant filtre dynamique selon l'une quelconque des revendications précédentes, dans lequel

est agencé au moins un premier détecteur (13) pour déterminer et gérer en option au moins une propriété dudit concentré fluide.

11. Procédé de séparation utilisant un séparateur formant filtre dynamique selon l'une quelconque des revendications précédentes, ledit procédé étant caractérisé en ce qu'il comporte les étapes consistant a :

a) alimenter ledit fluide d'alimentation jusqu'à l'intérieur de ladite chambre de concentré (4), un mouvement relatif entre ledit fluide d'alimentation et la paroi partiellement perméable (6) appliquant sur ledit fluide d'alimentation au moins une composante de son mouvement parallèle à la paroi partiellement perméable (6),
b) collecter des flux séparés de filtrat situés dans des chambres de filtrat partiel (5_1, 5_2, ..., 5_n)) à partir de différentes parties de ladite paroi partiellement perméable (6).

12. Procédé selon la revendication 11, comportant en outre la mesure d'au moins une propriété parmi le débit (cm^3/s), la densité, la composition, la concentration, la pression dudit filtrat desdits chambres de filtrat partiel (5_1, 5_2, ..., 5_n), etc.

13. Procédé selon la revendication 11 ou 12, comportant en outre l'extraction de concentré à partir de ladite chambre de concentré (4).

14. Procédé selon l'une quelconque des revendications de procédé précédentes, dans lequel lesdits moyens induisant un mouvement relatif comportent un élément agencé de manière rotative (11) formant un espace (12) entre ledit élément (11) et ladite paroi partiellement perméable (6), ledit disque (11) étant mis en rotation à une vitesse définie.

15. Procédé selon l'une quelconque des revendications de procédé précédentes, comportant en outre les étapes consistant à changer au moins un paramètre dudit séparateur formant filtre dynamique et/ou dudit procédé, et exécuter au moins une mesure d'un paramètre dudit procédé de séparation avant et après ledit changement.

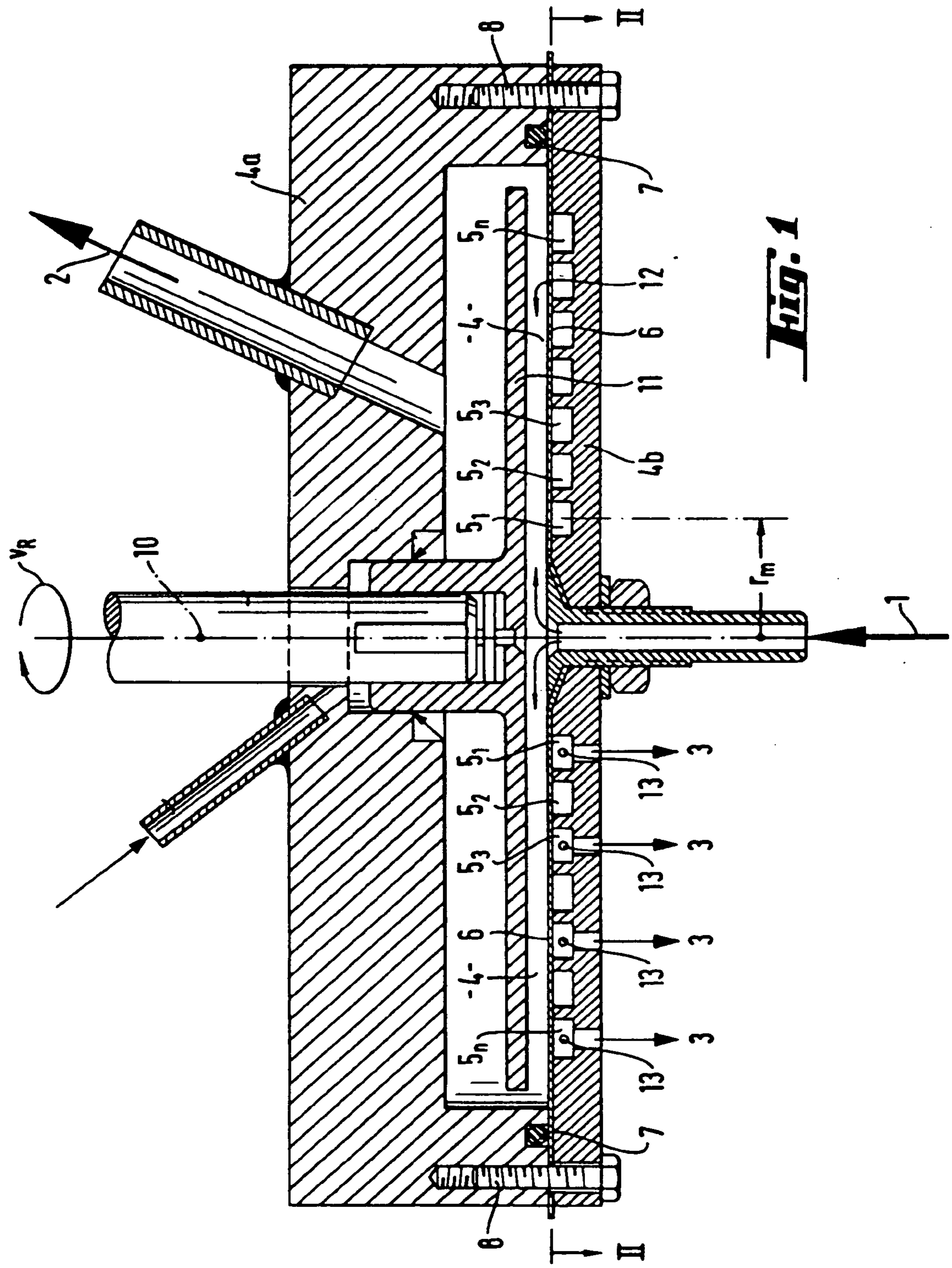

Fig. 1

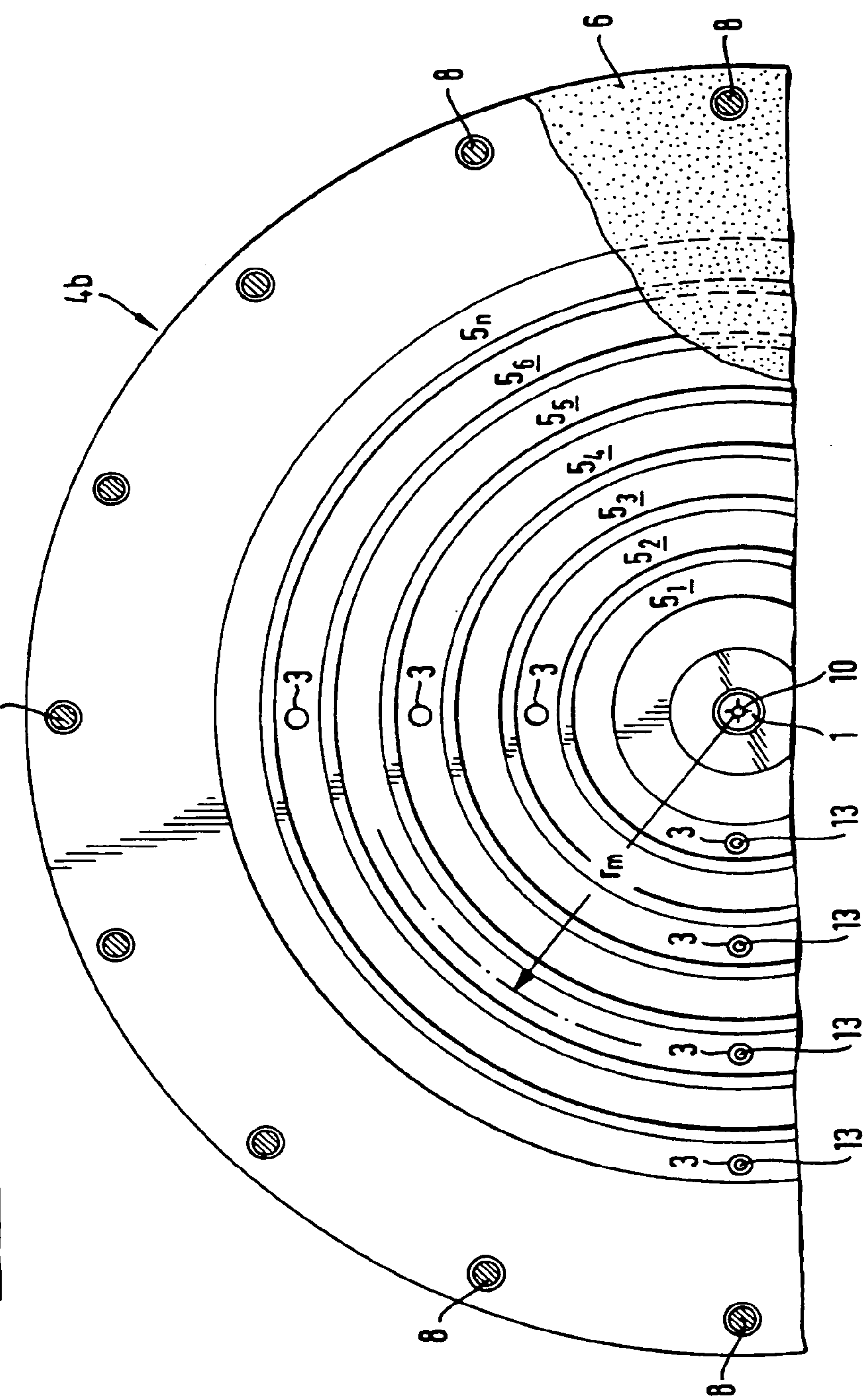

Fig. 2

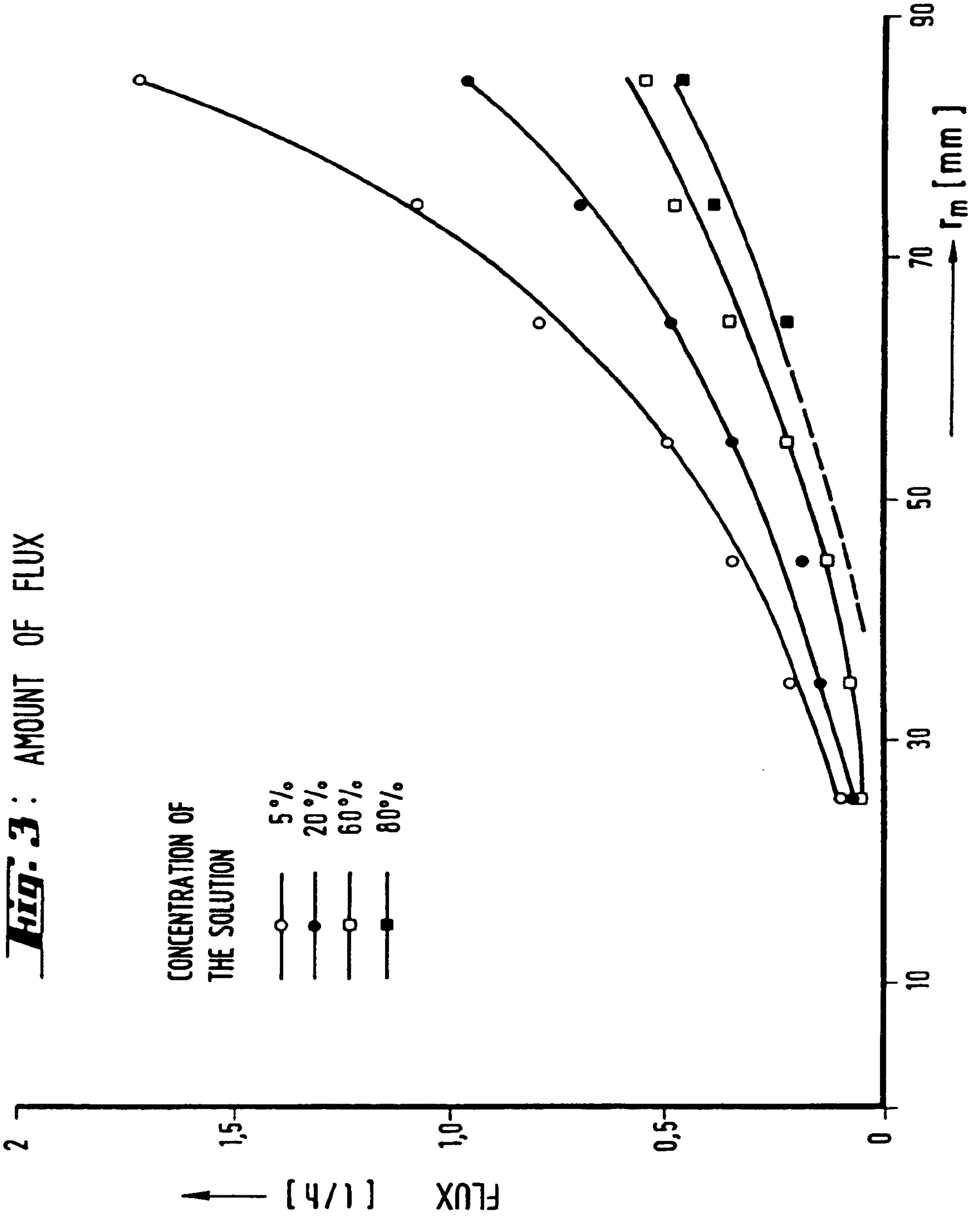

Fig. 3 : AMOUNT OF FLUX

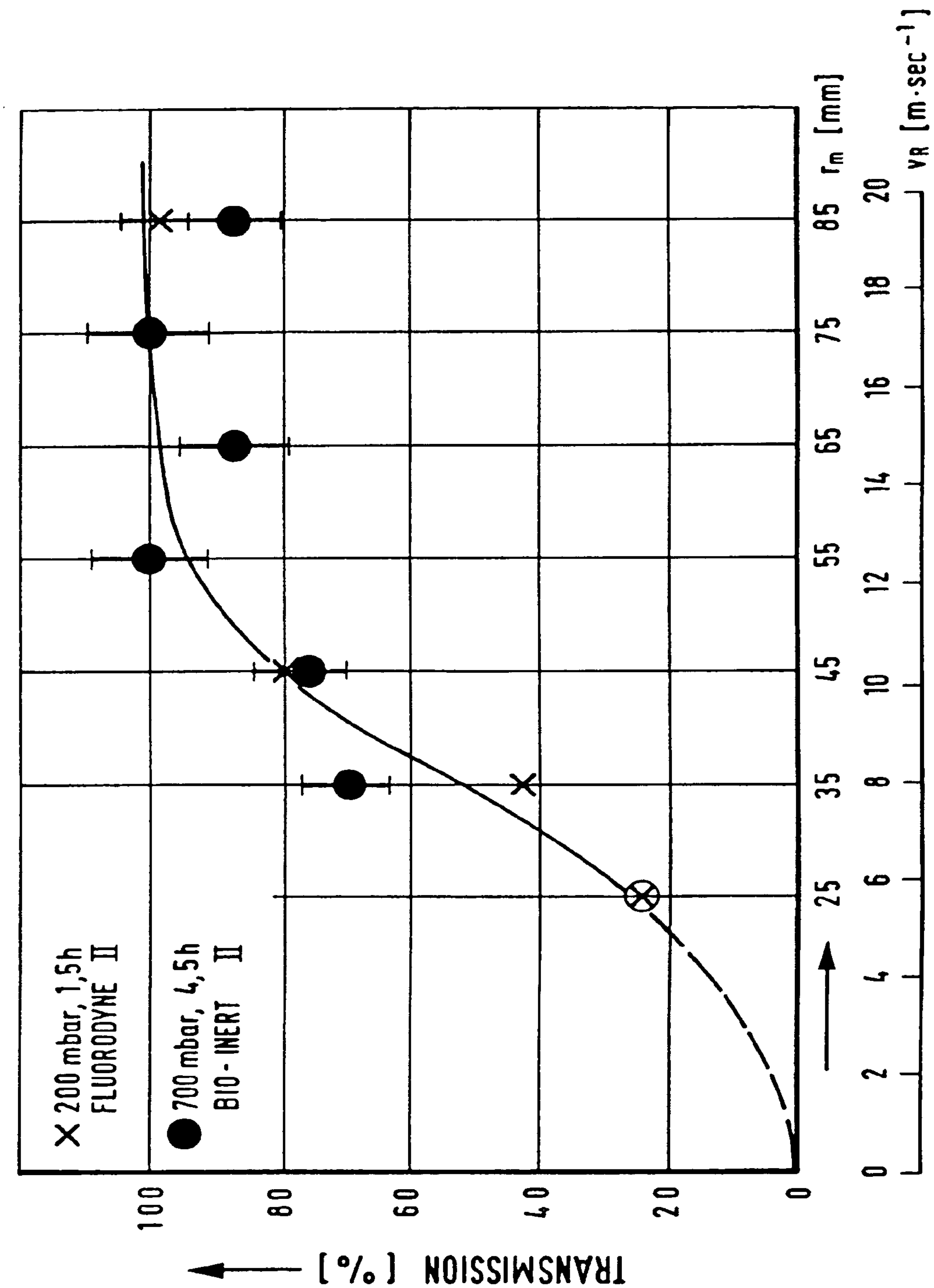

Fig. 4: PROTEINTRANSMISSION